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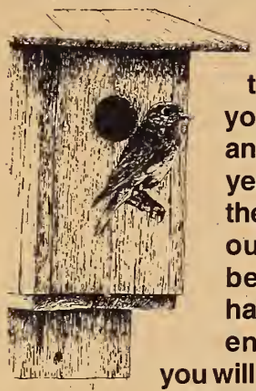
1720 PEACHTREE RD., NW ATLANTA, GA 30367

Tree Growth in the Urban Forest



What happens to a birdhouse if you hang it on a tree and come back in 2 years? Will it be at the same height or out of your reach because the tree has grown? By the end of this article you will be able to answer this question and others about how urban trees grow.

This bulletin is for those who love to plant and grow trees. Of course, trees grow the same way in the city as they do in the country (physiologically speaking), but we will emphasize tree growth in the city and discuss factors in the urban environment that affect this growth.

Understanding the way trees grow will help in their culturing and management. For instance, the timing of tree growth influences the success of such practices as planting and pruning. Understanding how roots grow may help determine where to plant certain species such as palms versus oaks. Knowledge of how trees grow in response to wind helps to make decisions about staking. And knowing how trees grow as they age will help to determine future management needs. This publication will help you answer questions about tree growth and this understanding may, in turn, help with decisions about cultural and management practices. Understanding and promoting good tree growth means a healthier urban forest.

WHAT IS TREE GROWTH?

Trees have six organs: leaves, stems, and roots (known as vegetative structures) and flowers, fruits, and seeds (known as reproductive structures). This bulletin discusses vegetative growth — that is the growth of leaves, stems, and roots.

Tree growth is the increase in size and number of leaves, stems, and roots.

WHAT KINDS OF TREES ARE THERE?

Trees are seed plants — that is they reproduce by seed. They are classified into gymnosperms and angiosperms. Gymnosperms are trees with seeds that develop on the surface or tip of an appendage such as a cone. Examples are cypress and pines. Angiosperms are trees with seeds borne within structures such as fruits (the seed is enclosed). Examples are oaks, elms, maples, and palms. This bulletin describes growth of both gymnosperms and angiosperms. Also, there's one more division among angiosperms that is necessary. Palms are angiosperms but they are different than oaks, maples, and elms, which are dicots, because palms are monocots and are related to grasses. This bulletin first reviews growth of gymnosperms and dicots; then because they grow very differently, a special section looks at palms.

WHAT CONTROLS GROWTH?

Tree growth is a response to the environment and to the tree's genetic make-up. The environment is made up of factors such as water, light, temperature, air, pests, and cultural practices. These factors impact physiological processes such as photosynthesis and respiration, and the final response is the tree grows vigorously or slowly. A tree's genetic make-up also influences the way a tree grows. Genetics means the

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species, seed source, or variety (Did it come from south Florida or North Carolina?), and family (Who were its parents?). These genetic characteristics along with its environment determine how a tree grows.

WHERE DOES GROWTH OCCUR?

Growth occurs in meristems. A meristem is a tissue that contains cells that have the capacity to divide and make new cells. Some of these new cells continue to function as meristematic cells. Other new cells grow and differentiate into structures such as roots and shoots.

Meristems can also produce new meristems — these are called primordia. For example, an apical meristem in a bud produces new meristems called leaf primordia — each single primordium will grow into a new leaf. Root primordia grow into new roots.

GROWTH ABOVE GROUND

Tree growth above ground includes shoot elongation, leaf growth, and diameter growth.

Shoot Elongation

Shoots grow in height or length in apical meristems located at the tips of branches (figure 1). What happens is — apical meristem cells divide, elongate, and differentiate. The steps that we can see are: (1) the bud at the tip of the branch opens, (2) leaves emerge and enlarge, and (3) the area between the leaves expands, namely the stem grows. Lateral (side) buds grow in the same way but often are dormant and do not grow until they are triggered to grow. Activities such as pruning can serve as this trigger.

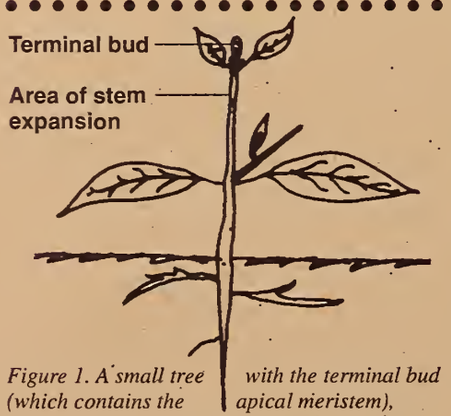

Figure 1. A small tree with the terminal bud (which contains the apical meristem), leaves (which have enlarged), and the area of stem growth between the leaves.

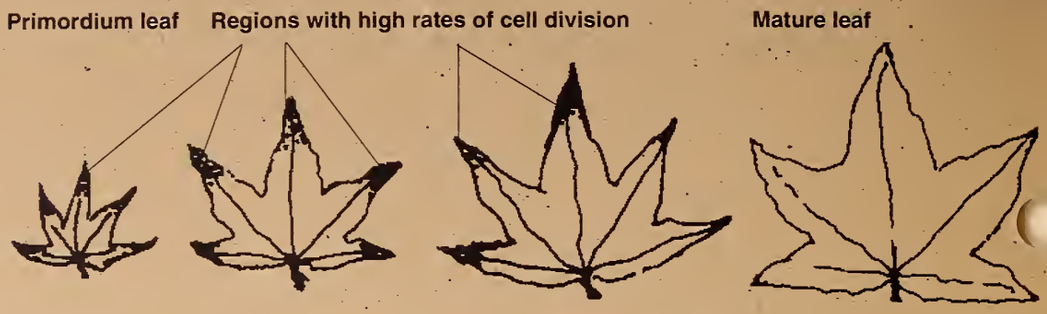

Figure 2. Each leaf has meristems. Rapid cell division at these meristems determines the final leaf shape.

Leaf Growth

On the surface of the apical meristem in the bud, a new meristem is formed. This new meristem is called a leaf primordium, and this is where cells divide and grow to form a leaf. The number of meristems on a leaf influence leaf shape (figure 2).

Soon after leaves develop, a new bud primordium (meristem) is formed at the base of each leaf stem. Once formed, this axillary bud has the capacity to become a branch, but may lie dormant for many years.

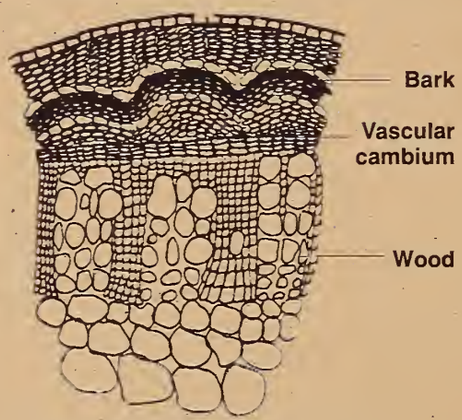

Figure 3. The vascular cambium produces wood on the inside and bark on the outside.

Diameter Growth

Between the wood and bark is a thin layer of dividing cells called the vascular cambium. This vascular cambium is a meristem which is only a few cells thick. This meristem divides, creating wood on the inside and bark on the outside (figure 3). Layer by layer these new cells increase the diameter of the trunk and branches. The wood cells are called xylem, which means wood in Greek; they carry water and minerals up from the roots. The bark cells are called phloem, meaning bark in Greek. These cells carry sugars and other materials produced by the plant.

Annual Rings

New layers of wood are added each year between the bark and the previous year's wood. These are called growth rings or annual rings and may be used to age a tree. Annual rings vary in size and thickness according to the season and environmental conditions when they are formed. Cells produced in the spring are larger with thinner cell walls. These are the light-colored rings, and the wood is called early or spring wood. Cells produced in the summer are smaller, and this late or summer wood has a higher density and darker color.

Bark

Trees have bark that protects the tree from pest attacks and environmental impacts such as fire and mechanical injury. Trees with thick bark are more resistant to injury than those with thin bark. As the tree grows in diameter, the bark has to give, forming ridges and cracks. Eventually the outer bark sloughs off.

GROWTH BELOW GROUND

Roots can grow in length (root elongation) and diameter, and new lateral roots can form.

Root Elongation

At the tip of a root is the root cap (figure 4). This cap protects the root, and it must be constantly replaced as it pushes through the soil. Behind the root cap is a meristem, which produces new cells for the root cap and for root elongation. These new cells elongate, divide, and differentiate into root parts. The root grows in length and pushes through the soil.

Root Diameter Growth

Many people don't think that roots grow in diameter, but they do! And root diameter growth is similar to

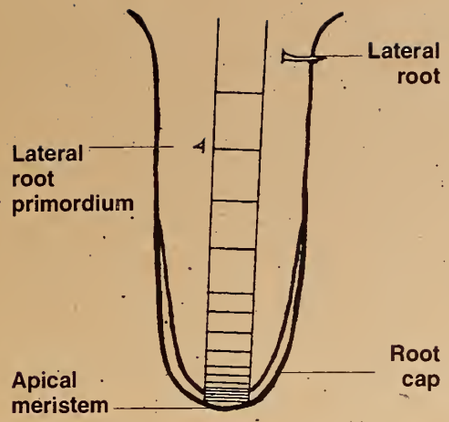

Figure 4. A root tip showing the meristem, which produces new cells for root elongation.

growth in the stem with the vascular cambium producing wood (xylem) and bark (phloem). A couple differences between root and shoot diameter growth are: (1) diameter growth is much more irregular in roots, resulting in roots that are oval or irregular shape, and (2) there is greater variation in root diameter with age and with horizontal roots compared to vertical roots.

New Root Growth

Roots can also grow new lateral roots that branch off the main root. Some cells located in a layer inside the root produce a new root primordium (figure 4). This new meristem divides and elongates, pushing the new root out through the parent root and into the soil.

PALMS

There are two major points to be made about palm growth: (1) palms only have one terminal growing point, and (2) palms do not grow in diameter as they age. This section shows how palms grow taller and grow roots and how the one bud influences their form compared to other trees.

Shoot Elongation

The apical meristem lies in a depression at the crown of the stem (figure 5). Within this meristem is a soft mass of leaves and leaf bases. In this crown there is continuous production of leaf meristems (primordia). There may be up to 50 meristems in the apex. The leaves grow in sequence with one leaf emerging as a spear at a time. The meristem at the base of the leaf causes the leaf to elongate, grow bigger and thicken and eventually equal the diameter of the palm stem.

Root Growth

Root growth occurs near the root cap just as in gymnosperms and dicots. However, just like shoot growth of the stem, there is no diameter growth of palm roots. The roots remain the same diameter for long distances (giving the appearance of a spaghetti-like root system). Descending roots are for anchorage. Most of the horizontal roots are in the top 40 centimeters (15.7 inches) of soil and grow out from the palm about 4 meters (13 feet).

SEASONAL GROWTH, LIFESPAN AND AGING

Different parts of trees grow at different times of the year, and the pattern varies by species and climate. In one typical pattern trees begin with shoot growth in the spring, followed by trunk diameter growth and then root growth. However, this growth can occur in any order, and root growth may be year-round or have two growing periods per year. Young trees grow longer in the growing season than older trees. Length of active growth is determined by temperature, day length, and water.

Tree species have a wide range of lifespans. For example, while peach trees may live only 30 years, oaks may live several hundred years, cypress 1,600 years, and bristlecone pine up to 5,000 years in an undisturbed site in the forest (Kramer and Kozlowski 1979). Forest tree species may undergo stress when planted in the city. The average tree in the downtown may live only 13 years, one tenth the lifespan of a tree at a rural site (Skiera and Moll 1992).

What happens to trees as they age? Some of the likely occurrences are the following: (1) growth slows down, (2) trees are more susceptible to diseases and insects, (3) the tops of the trees are more likely to die back, (4) wounds heal more slowly, (5) there are fewer leaves relative to size of the tree, and (6) the number of dead branches increases. All of these characteristics can also be seen in urban trees as they begin to die and/or show signs of poor health.

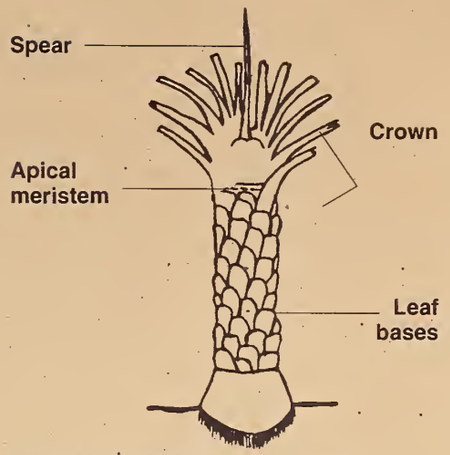

Figure 5. A palm has one apical meristem which produces all its leaves.

GROWTH AND TREE FORM

The way trees grow affects their form. The apical bud is the bud at the tip of each branch; lateral buds are on the sides of the branches. Apical dominance means that the apical bud at the tip of the stem controls and inhibits growth of lateral buds. Most palms only have one apical bud. Therefore palms usually grow straight with no branching; they are an extreme example of apical dominance. The main stem or leader of pines is prominent, but branches formed by lateral buds change the form, resulting in less apical dominance than palms. An oak tree has very little apical dominance, with several branches dominating the crown.

EXAMPLES OF THE URBAN ENVIRONMENT'S INFLUENCE ON GROWTH

Urban trees are often subjected to a tremendous amount of stress. Soils are compacted, trees are over- or incorrectly-pruned, roots are given very little space to grow, trees are improperly staked, and on and on. A few of the stress-induced practices and environmental conditions are discussed briefly along with how they affect growth.

Pruning

What happens when you prune a tree? If you prune the apical buds, the lateral buds are released and new shoots grow. If you prune older, large-diameter stems, two things may happen: (1) dormant buds, produced long ago during primary growth, can now grow into new branches, and (2)

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new meristems arise and produce new buds and shoots. This growth of new branches is most likely to occur in angiosperms — everyone has seen sprouts from the stump of a freshly cut oak, maple, or elm. Pine trees, however, do not have these dormant buds and will not sprout. Of course, if you remove the apical bud from a palm, it will die — remember, most palms only have one bud at the top of the tree.

Staking

How does staking affect growth? When trees are planted, they are often staked. However, studies have shown that trees that are allowed to sway in the wind are sturdier. Staked trees tend to be less stable and sometimes topple when stakes are removed and trees are exposed to wind. This can be explained by looking at growth differences. When trees blow in the wind there is a redistribution of the amount and nature of diameter growth on the leeward and windward sides of the tree trunk. Reaction wood is formed, and this wood has larger and thicker walled cells than other wood. Hence when exposed to wind a tree becomes sturdier and can tolerate wind better. For this reason, do not stake young trees unless they absolutely will not stand up without a stake. Remember palms do not have cambial (diameter) growth, so staking palms is okay and often necessary until new roots stabilize the palm in the landscape.

Compacting the Soil

Soil conditions in urban plantings are often ignored, resulting in many tree health problems. Trees often have limited rooting space and are similar to large potted plants. Soil compaction can occur due to such things as construction equipment, sidewalks and streets, and footsteps. What happens to growth when tree roots are in compacted soil? Studies show that trees grown in highly compacted soil have less root volume and weight because roots cannot penetrate compacted soil. And this translates into reduced shoot height and overall growth. Compacted soil in the city means roots cannot grow, water cannot permeate into the soil, and nutrient uptake is reduced, resulting in poor tree growth. Of course, the ultimate effect is poor tree health and death. Some ways to avoid compaction are: (1) mix organic matter into the soil, (2) prevent vehicles from operating beneath the tree canopy, and (3) when construction traffic must work around trees make sure it is when the soil is dry (wet soil is more easily compacted) or spread a thick layer of coarse mulch beneath the canopy.

CONCLUSIONS

Trees grow in response to their environment and genetic make-up. Environmental factors such as high temperature or soil compaction influence physiological processes such as photosynthesis and, in turn, impact growth. Meristems are areas within the tree where growth occurs. Most trees grow in shoot length and diameter and root length and diameter. Palms, however, have only one growing tip and do not grow in diameter. A tree's form is controlled by branch orientation and by the amount of apical dominance. Altering the environment or management practices to decrease stress, and selecting the right tree for the right place will promote growth and longevity.

And, finally, as the tree ages and grows, does the birdhouse move up the tree and out of your reach? No! Why not? Remember a tree only grows in height at apical meristems at the tips of branches. At the height of the bird-house only trunk diameter growth is occurring.

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